Ultrafast Particle Plasmon Dynamics of Waveguide-Plasmon Polaritons

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The interaction between optical waveguide modes and particle plasmon resonances in so-called metallo-dielectric photonic crystal slab structures leads to strong coupling phenomena [1]. New collective states are formed which can be described by means of a polariton model (a so-called "waveguide-plasmon polariton"). This leads to a drastic modification of the optical response of the polaritonic system.

In the present work, the dephasing times of the polariton resonances in a two-dimensional metallo-dielectric photonic crystal slab structure are investigated. All measurements are based on a nonlinear interferometric autocorrelation technique which allows the measurement of the dephasing times in the time domain.

When tuning the waveguide mode to the particle plasmon resonances by an appropriate structuring of the photonic crystal period, the photonic density of states is strongly modified. The change in the density of states results in a reduced radiative decay and therefore a prolonged dephasing time of the waveguide-plasmon polariton compared to single particle plasmons. By fitting the measured autocorrelation traces with a simple damped oscillator model [2], we can extract a lower limit of the dephasing time of the appearing polariton branches. We found a dephasing time of T_2=30 fs which is nearly three times as long as the uncoupled particle plasmon dephasing time [3].

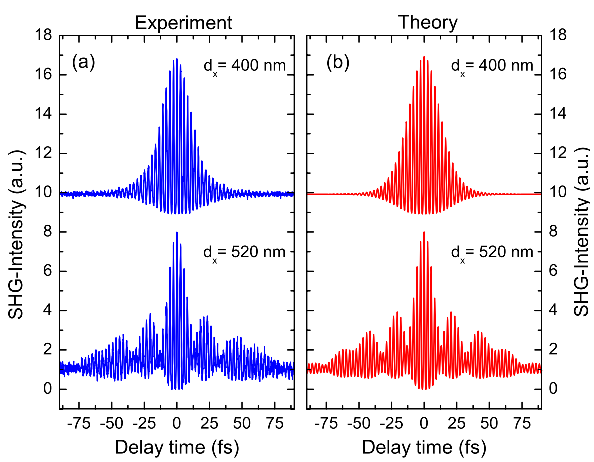

Fig. 1: Measured (a) and calculated (b) second-order autocorrelation signal of a 13 fs laser pulse interacting with the metallic photonic crystal slab for two photonic crystal periods.

In conclusion, we have demonstrated experimentally that the dephasing time of the coherent excitation of particle plasmons can be tailored by an appropriate structuring of the photonic crystal period in metallic photonic crystal structures.

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